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PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

1832–33. No. 2.

April 1.

SIR THOMAS MAKDOUGALL BRISBANE, K. C. B.
President, in the Chair.

The following Donations were presented :—

Annual Report of the Yorkshire Philosophical Society for 1832. —*From the Society.*

Collections of Specimens from the Volcanic District of the Rhine. —*From Professor Forbes.*

The following communications were then read :—

1. Continuation of "Experimental Researches regarding certain vibrations which take place between Metallic Masses having different Temperatures." By James D. Forbes, Esq. Professor of Natural Philosophy in the University of Edinburgh.

The vibrations here referred to, are those which with their accompanying sounds were first observed by Mr Arthur Trevelyan, and communicated to this Society in a paper published in the 12th vol. of their Transactions. The author of the present paper undertook the inquiry as soon as the remarkable fact was announced by Mr Trevelyan, and was induced to prosecute it to a considerable extent experimentally, in consequence of being dissatisfied with the only plausible explanation yet offered,—that of the successive expansions of the cold metal by the hot one at the point of contact at each suc-

cessive vibration, which was conceived to afford the necessary impulse or maintaining power.

In this paper, the phenomena of sound are first discussed, which, with Mr Faraday, the author imputes solely to the number of vibrations taking place in a given space of time. This seems completely proved by observation, and the note depends upon the frequency of the oscillations, which have been observed as high as between 700 and 800 in a second, and must often be greatly more frequent. The phenomena of vibration are next considered as affected by the nature of the metals, by the form of the masses, and by temperature. The order of the metals as vibrators, is the following, meaning that the cold metal must always stand lower in the list than the hot one, and that the force or intensity of vibration is, generally speaking, proportional to the space intervening between two metals on the list, *Silver, Copper, Gold, Zinc, Brass, Platinum, Iron, Tin, Lead, Antimony, Bismuth.* Antimony and Bismuth are placed at the bottom of the list, because no other metal is capable, under any circumstances which have been examined, of producing vibrations in conjunction with those two metals: they are the only metals yet observed which, when heated, do not vibrate on cold lead.

From experiments detailed at considerable length in the paper, the author is led to the following practical conclusions, which, whatever may be the fate of the hypothesis which he is disposed to found upon them, will, he conceives, be viewed as valuable in themselves. 1. As far as has been observed, the vibrations never take place between substances of the same nature. 2. Both substances must be metallic. 3. The vibrations take place with an intensity proportional, within certain limits, to the difference of the conducting powers of the metals for *heat* (or *electricity,**) the metal having the least conducting power being necessarily the *coldest.* 4. The time of contact of two points of the metals (between which the oscillations take place) must be longer than that of the intermediate portions. 5. The impulse is received by a distinct and separate process at each contact of the bar with the block, and in no case is the connection of these points in any way essential. 6. The intensity of vibration is (under certain exceptions), proportional to the difference of temperature of the two metals.

From these data, the author first endeavours to show, that the hypothesis of expansion is untenable, by tracing closely the process of communication of heat, and proving that it must lead to several conclusions totally at variance with experiment, and particularly

* See the abstract of a former paper on the identity of those arrangements.

that as far as conducting power for heat is concerned, both the hot and the cold metal should possess it in the highest degree. The author is led by the striking analogy of the powerful repulsive action of electricity in passing from a good to a bad conductor, to infer a similar property in heat, which, without entering into any speculations as to the nature of those principles, appear to have a repulsive character in common indicated by a tendency to diffusion and equilibrium. He conceives, that while some very delicate experiments in France have given indications of the actual force exerted by heat equally diffused through two adjoining masses, that the energy in this case is produced by the accumulated repulsive power in the last particles of the good conductor, the current (without meaning any thing hypothetical by the term) being suddenly cut short by the resistance opposed by the inferior conductor to its passage. The destructive energy of electricity indicative of its repulsive force, is never exerted in a state of equilibrium, but by the accumulation of separate repulsive energies which take place in the transition from a good to a bad conductor, or during its passage through the latter.

2. On the Equations of Loci traced upon the surface of the Sphere, as expressed by spherical co-ordinates. By T. S. Davies, Esq. F. R. S. E.

This paper is intended as a necessary supplement to the paper bearing the same title already printed in the Society's Transactions, though but an abridgment of a larger one which the author had prepared on the subject. Particular circumstances induced him to alter the plan he had originally contemplated, and instead of a complete development in detail of his researches and his views, he has only on the present occasion given so much of his results as were necessary to bring the system of polar spherical co-ordinates to a state analogous to that in which plane polar curves has long been stationary, one point of the analogy excepted, viz. where the author has extended the method of treating tangents and normals, and the consequent investigations dependent on these, by giving the polar equations of those lines, instead of merely examining the relation between the radius-vector, and perpendicular upon the tangent. In a note the equations of the tangent and normal, to plain curves, is given from first principles; and the analogy between plane and spherical curves is shewn to be remarkably close.

Amongst the properties of spherical curves, the following curious one occurs.

If the pole of a loxodrome to rhumb α be made the centre of another equal sphere, the visual cone under which the loxodrome will appear, will cut the second sphere (the eye being at centre of first sphere) in a curve, whose equatorial subtangent is constant, and equal to α: and if conversely, the pole of the spherical logarithmic (the equisubtangential curve just mentioned) be made the centre of an equal sphere, the visual cone of this logarithmic, seen from the centre of its own sphere, will cut the second sphere in a loxodrome whose rhumb is equal to the subtangent of the logarithmic.

The author expresses his intention of discussing in a separate work the singular points of spherical curves, certain new systems of co-ordinates, and other classes of research, which, on account of the length to which they necessarily extend, were not adapted to the Transactions of the Royal Society.

3. Experiments and Observations on the Arterialization of the Blood. By William Gregory, M. D., F. R. S. E. and W. J. Irvine, Esq.

The object of these experiments was to ascertain some of the circumstances under which the blood changes in colour, from the dark venous to the florid arterial hue.

Dr Stevens first showed, that the venous clot deprived of its serum by washing, remained dark even when in contact with oxygen; and that the addition of a saline solution caused it immediately to become florid. He stated also, that a strong saline solution would cause this change in an atmosphere so highly charged with carbonic acid as to prove rapidly fatal to animals.

It appeared to the authors necessary to ascertain whether this effect took place in pure carbonic acid, containing no free oxygen, as the atmosphere used by Dr Stevens most probably did; and they also proposed to extend their observations to other gases, likewise free from oxygen. They accordingly prepared pure nitrogen, hydrogen, and carbonic acid, removing the last traces of oxygen by means of potassium. The water with which the clot was washed, and the saline solution used in the experiments, were deprived of atmospheric air by being boiled and allowed to cool in close vessels. The clot was then introduced into the gases over mercury, and as soon as the strong saline solution came in contact with it, the colour, in all the three gases, changed from black to bright red, and the same change was found to take place in the Torricellian Vacuum.

It was obvious, therefore, that a strong saline solution could change the colour of the blood from venous to arterial without the contact of oxygen, or indeed of any gas whatever.

But in blood, the colouring matter is in contact, not with a strong saline solution, but with a very dilute one, viz. the serum. It was necessary, therefore, to see whether the washed clot, placed in contact with serum or a weak solution of salt, in the same gases, would change its colour. On repeating the experiments, both with serum and a solution of salt in water of equal strength to the serum, no change whatever took place, until atmospheric air or oxygen gas was admitted.

The conclusions of Dr Stevens, therefore, must be somewhat modified. It is true, as he states, that the presence of saline matter is essential to the change of colour: But it is obvious, that there is an essential difference between that change as it occurs in the lungs, where serum is present, and as it appears out of the body when a strong saline solution is employed. In the former case, oxygen is necessary: In the latter, the change of colour is independent of the presence of any gas whatever. We must, therefore, be cautious how we reason by analogy from the one class of phenomena to the other.

April 15.

Professor RUSSELL, Vice-President, in the Chair.

The following Donations were presented:—

Memoires présentés par divers Savans à l'Academie Royale des Sciences de l'Institut de France. Tome 3.—*From the Royal Institute of France.*

Quarterly Journal of Agriculture, 3 vols., and Prize Essays and Transactions of the Highland Society of Scotland, (New Series,) 3 vols.—*From the Society.*

The following Communications were then read:—

1. Observations on the Lines of the Solar Spectrum, and on those produced by the Earth's Atmosphere, and by the Action of Nitrous Acid Gas. By Sir David Brewster, LL. D., F. R. S.

The author was led, in prosecution of his researches on the absorptive action of transparent media of light, which have been partly communicated in previous papers to the Society, to examine the influence of coloured gaseous bodies. Iodine vapour was one of these, and its action was found of a similar character to that of fluids having a similar tint. Nitrous acid gas presented a far more extraordinary phenomenon.

The Spectrum of Newton, and of all the philosophers of the 18th century, was a parallelogram of light with circular ends, in which the *seven* colours gradually shaded into each other without any interruption. The illumination was a maximum in the yellow rays, and the light decayed by insensible degrees towards the red and violet extremities. In the year 1808, Dr Wollaston conceived the happy idea of examining a beam of day-light that passed through an aperture only the 20th of an inch wide, and he was surprised to see it crossed by seven dark lines, perpendicular to its length.

About ten or twelve years afterwards, the celebrated optician, Joseph Fraunhofer, without knowing what had been done by Dr Wollaston, observed the spectrum formed by the sun's light transmitted through small apertures; and by applying a telescope behind the prism, he discovered about 600 parallel dark lines traversing the spectrum. As no such lines appeared in the spectra of white flames, Fraunhofer considered them as having their origin in the nature of the light of the sun. The strongest of these lines were seen in the spectra of the Moon, Mars, and Venus; and by means of very fine instruments, he was able to detect one or two of them with other new lines in the spectra of Sirius and Castor.

Upon examining with a fine prism of rock-salt, with the largest possible refracting angle (nearly 78°), the light of a lamp transmitted through a small thickness of nitrous acid gas, whose colour was a pale straw-yellow, the author was surprised to observe the spectrum crossed with hundreds of lines or bands far more distinct than those of the solar spectrum. The lines were sharpest and darkest in the violet and blue spaces, fainter in the green, and extremely faint in the yellow and red spaces. Upon increasing, however, the thickness of the gas, the lines grew more and more distinct in the yellow and red spaces, and became broader in the blue and violet, a general absorption advancing from the violet extremity, while a specific absorption was advancing on each side of the fixed lines in the spectrum. It was not easy to obtain a sufficient thickness of gas to develope the lines at the red extremity, but the author found that heat produced the same absorptive power as increase of thickness, and by bringing a tube containing a thickness of half an inch of gas to a high temperature, he was able to render every line and band in the red rays distinctly visible.

The power of heat alone to render a gas which is almost colourless as red as blood without decomposing it, is in itself a most singular result ; and the author succeeded in rendering the same pale nitrous acid gas so absolutely black by heat, that not a ray of the brightest summer's sun was capable of penetrating it. In making the experiment, the tubes frequently exploded ; but by using a mask of mica and thick gloves, and placing the tubes in cylinders of tinned iron with narrow slits to admit the light, there is little danger of any serious accident.

The author then points out various practical applications which may be made of this discovery, especially its substitution for the more difficult process, when Fraunhofer's lines in the solar spectrum are employed, of determining the dispersive powers of substances. Since the absorptive action by increasing the thickness of the medium generally *enlarges* the lines already defined, these may be rendered as distinct as may be required, which it is impracticable to do with the solar lines, and hence the difficulty of applying these to useful purposes. The lines in the sun's light, and those of the nitrous acid gas spectrum, when directly compared, have a strong analogy ; but in order to establish it completely, the author found Fraunhofer's map of the solar spectrum insufficient, and was induced to undertake the laborious task of going over the whole ground. By dint of perseverance, and by the use of some original methods, he has been enabled, with very inferior instruments, to distinguish about 2000 lines instead of the 354 which Fraunhofer had laid down.

The author watched narrowly the state of the defective solar lines at different seasons of the year, in order to observe if any change took place in the combustion by which the sun's light is generated, or in the solar atmosphere through which it must pass. Such changes he found to be very general in every species of terrestrial flame. The definite yellow rays which exist in almost all white lights, flicker with a variable lustre, and analogous rays in the green and blue spaces proceeding from the bottom of the flame, exhibit the same inconstancy of illumination. In the course of the winter observations, he observed distinct lines and bands in the *red* and *green* spaces, which at other times wholly disappeared ; but a diligent comparison of these observations soon shewed that these lines and bands depended on the proximity of the sun to the horizon, and were produced by the absorptive action of the earth's atmosphere.

The atmospheric lines, as they may be called, or those lines and bands which are absorbed by the elements of an atmosphere, have their distinctness a maximum when the sun sinks beneath the horizon. The study of them consequently becomes exceedingly difficult in a climate where the sun, even in a serene day, almost always sets in clouds; but the author has been able to execute a tolerably accurate delineation of the atmospheric spectrum.

Most of the lines thus widened by the atmosphere, are faint lines previously existing in the spectrum.

The author's observations, whilst they indicate the remarkable fact, that the same absorptive elements which exist in nitrous acid gas exist also in the atmospheres of the sun and of the earth, lead us to anticipate very interesting results from the examination of the spectra of the planets. Fraunhofer had observed in the spectra of Venus and Mars some of the principal lines of the solar spectrum. This, indeed, is a necessary consequence of their being illuminated by the sun; for no change which the light of that luminary can undergo is capable of replacing the rays which it has lost. But while we must find in the spectra of the planets and their satellites all the defective lines in the solar spectrum, we may confidently look for others arising from the double transit of the sun's light through the atmospheres which surround them.

2. Notice relative to the Pigmentum Nigrum of the Eye. By Thomas Wharton Jones, Esq.

The objects proposed by the author of this paper are,—

1. To correct certain opinions prevalent with regard to the membrane of Jacob, this having been frequently comfounded with another, the structure of which forms the immediate subject of the paper.

2. To shew that the *Pigmentum Nigrum* is not a mere mucus or varnish exhaled by the surfaces on which it is found, but is deposited in a membrane distinct from the choroid, which possesses a peculiar structure hitherto unknown. This membrane, being the seat of the pigment, but not the pigment itself, which may or may not be present, the author proposes to call the *Membrane of the Pigment.*

If a portion of this membrane be examined by the aid of the microscope, it is seen to consist of very minute hexagonal plates, in which are deposited numerous black particles, which are to be considered as properly constituting the pigment, but not essential to the hexagonal plates composing the membrane, because these may, and do, exist without the black particles.

In the eye of the Albino Rabbit, the author found, as he had *a priori* expected, the membrane of the pigment to exist. The plates composing which, however, are still less developed than those of that part of the membrane which lies over the tapetum, in the eyes of the horse, ox, &c. They are in fact not hexagonal, but circular, a structure similar to which the author has found in the eye of a very young human fœtus.

Behind and around the ciliary processes, and on the posterior surface of the iris, the membrane of the pigment ceases to present the hexagonal structure, although still composed of small irregularly rounded masses of about the same size as the hexagonal plates, to which they are evidently analogous.

This change in the structure of the membrane of the pigment, which is only partial in the eyes of the Mammiferæ, the author has found to obtain in its whole extent, in the eyes of those animals lower in the zoological scale which he has examined, except in the eye of the Cuttlefish, in which there is an approach to the hexagonal structure in that part of the pigment which lies on the posterior surface of the part in which the crystalline lens is fixed.

May 6.

Sir THOMAS MAKDOUGALL BRISBANE,
President, in the Chair.

The following Donations were presented :—

Geological Sketch of the Vicinity of Hastings. By W. H. Fitton, M. D., &c.—*From the Author.*

Notes on the Progress of Geology in England. By W. H. Fitton, M. D.—*From the Author.*

Abstracts of the Papers printed in the Philosophical Transactions of the Royal Society of London, from 1800 to 1830 inclusive. 2 vols.

Proceedings of the Royal Society of London, No. 11.

List of the Fellows of the Royal Society of London for 1832–33.

Addresses delivered at the Anniversary Meetings of the Royal Society of London on November 30. 1831, and November 30. 1832.—*From the Royal Society of London.*

Memoirs of the Royal Astronomical Society. Vol. V.—*From the Society.*

Astronomische Nachrichten. No. CCXXXIII. to CCXXXVIII.—*From M. Schumacher.*

Nova Acta Physico-Medica Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vols. X. XI. XII. XIII. XIV. and XV. Part I.—*From the Imperial Academy of Bonn.*